Lecture 2 (2020/2021)

In living organisms, smaller molecules are often attached to each other to make larger molecules. These "smaller" molecules are sometimes called **monomers,** and the larger molecules made from these monomers are called **polymers**. When naming and identifying molecules, it is important to recognize certain features of the molecule. For example, one part of a molecule is often very reactive or will combine with other molecules. The parts of specific regions of a molecule that are important are often called **"functional groups".** The functional groups are important because they are the parts that often determine how a molecule functions or interacts with other molecules.

There are several functional groups that are important in biology. Make sure you can recognize and name the various functional groups illustrated below, and also be able to tell what types of molecules often have them (Figure 2.1a).

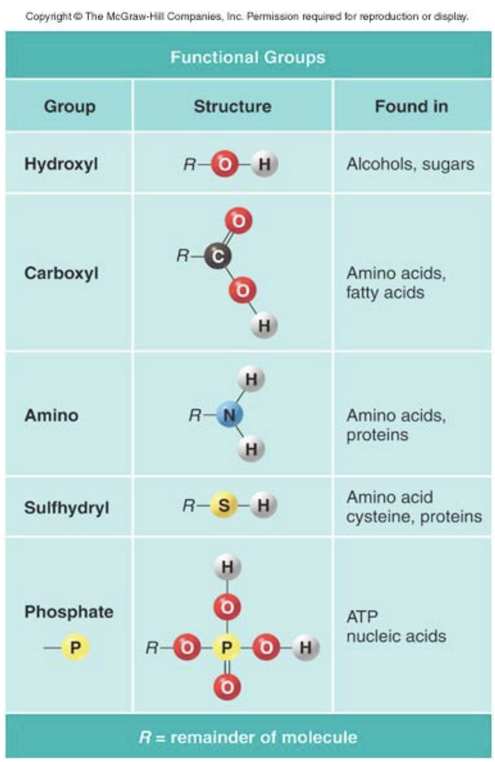


Figure 2.1a

Macromolecules

There are four types of macromolecules (i.e., big molecules) that we commonly deal with in this class. They are carbohydrates, lipids, proteins, and nucleic acids.

Carbohydrates

Carbohydrates can be identified by the fact that they have a C:H:O ratio of 1:2:1. That means that for every carbon there should be 2 hydrogens and 1 oxygen. This is not always exactly true, but this method works pretty well. Also, carbohydrates have many hydroxyl functional groups.

There are three types of carbohydrates (based on size). They are **monosaccharides, disaccharides,** and **polysaccharides**. Figure 2.2a is a picture of a monosaccharide. This particular monosaccharide is called glucose.

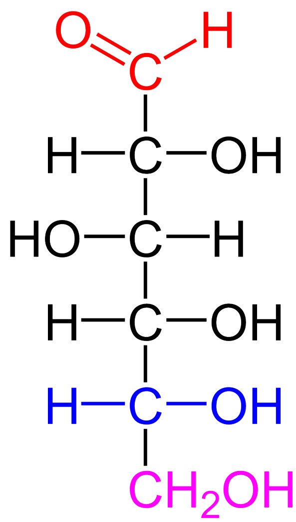


Figure 2.2a

Many macromolecules have more than one form or more than one way they can occur. Glucose, for example, can also be found in a ring form (it is probably this way more often in nature). When rings are drawn, each corner of the ring should have a carbon atom unless you are told otherwise (by the placement of something else in that region such as oxygen or nitrogen). Here is a picture of the ring form of glucose (Figure 2.3a):

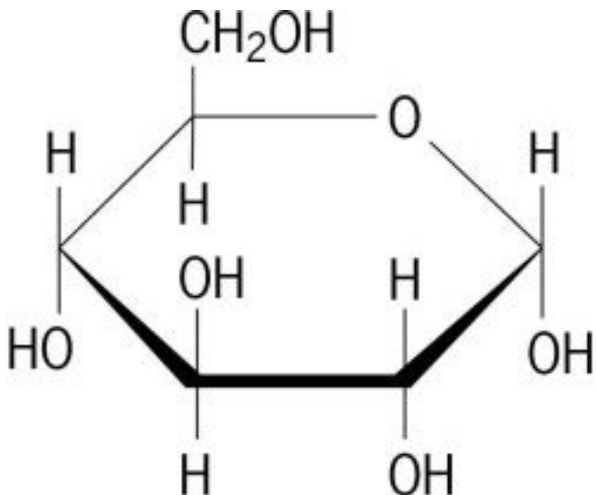


Figure 2.3a

As I mentioned, there are three different types of carbohydrates. The differences are based on size: monosaccharides are the smallest, disaccharides are made up of two monosaccharides, and polysaccharides are made up of many monosaccharides. There are thousands and thousands of different types of carbohydrates falling into these categories. I want you to know these specific carbohydrates, what category they fall into, and what they are used for (Table 2.1a):

Table 2.1a

Name of carbohydrates	Category	Importance
Glucose	Monosaccharide	Energy use
Sucrose	Disaccharide	Energy use
Starch	Polysaccharide	Energy storage in plants
Glycogen	Polysaccharide	Energy storage in animals
Cellulose	Polysaccharide	Structure of plant cell wall
Fructose	Monosaccharide	Energy use

Lipids

Lipids are macromolecules that are made almost entirely of carbon and hydrogen. THEY DO NOT have the ratio of carbon:hydrogren:oxygen as found in carbohydrates. Lipids are a very diverse group of macromolecules and include **steroids, fats**, and **phospholipids.** Below is an example of a steroid called **cholesterol (Figure 2.4a).**

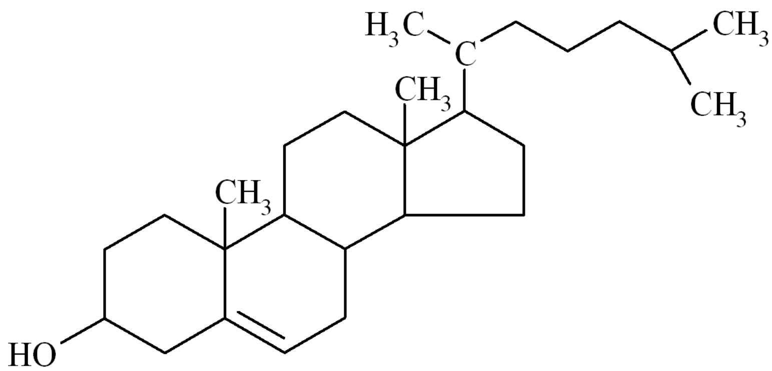


Figure 2.4a

Here is another type of lipid. The picture below is a fat. This particular fat is what we call a **SATURATED FAT** because it contains no double bonds in the long carbon/hydrogen chains. Fats are made from 2 different kinds of molecules: A 3 carbon glycerol and 3 fatty acid chains. These particular fats (without double bonds) are called Saturated Fats (Figure 2.5a).

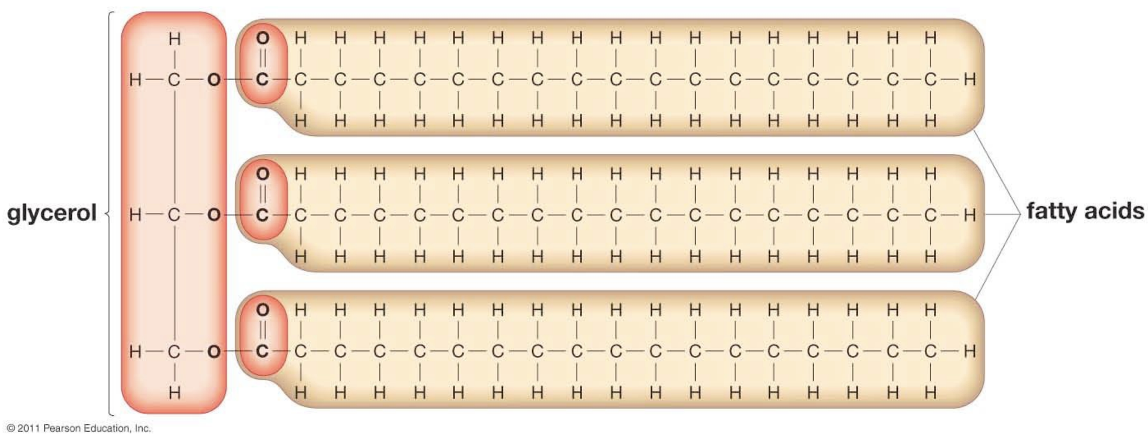


Figure 2.5a

Below is a picture of part of an **unsaturated fat**. In this case, you can only see one of the chains of carbon and hydrogen (one of the fatty acids chains). Double bonds, as found in unsaturated fats, causes the chains to "bend" as you can see in this picture (Figure 2.6a).

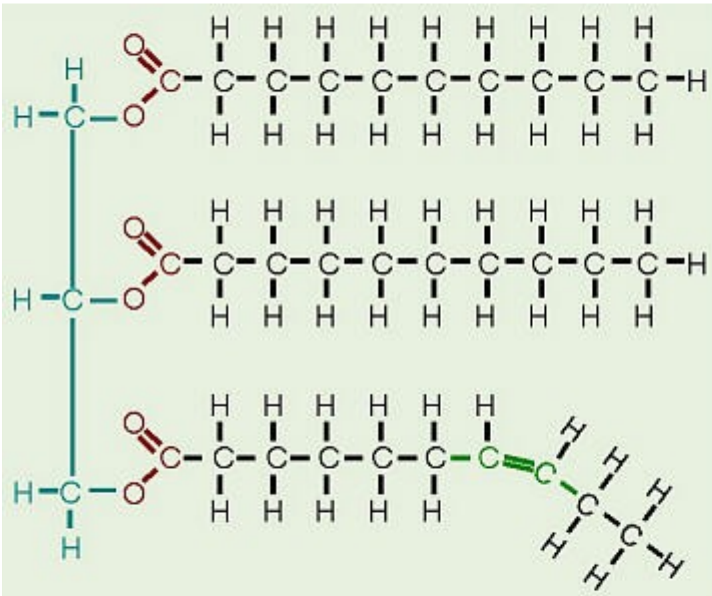


Figure 2.6a

When a fat has one double bond, it is called a monounsaturated fat. When it has two or more, it is called a polyunsaturated fats. These are considered the "good fats" (although still very high in calories) when compared to the saturated fats. Also, watch out for trans-fats and "partially hydrogenated vegetable oil" (or anything "partially hydrogenated"). These are considered to be VERY bad fats for your health the most part.

Proteins

The next group of macromolecules that are important in biology are **proteins**. Proteins are very important molecules in biology. Proteins are made out of smaller units (monomers) called **amino acids.** Here is a generalized amino acid (Figure 2.7a):

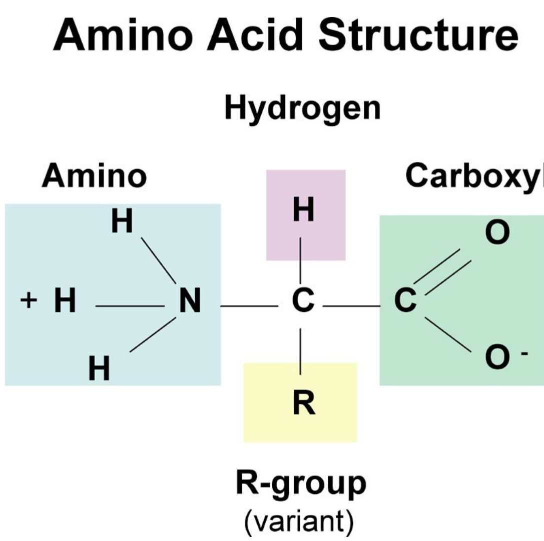


Figure 2.7a

You should note the "amino group" (which is the nitrogen and the two hydrogens) and what is called the **carboxylic group** (the carbon with the double bonded oxygen and oxygen with a negative charge (or, a hydrogen atom attached). These are two of the functional groups that you learned about earlier. All amino acids have these two main parts. What makes one amino acid different from another is the shaded region. You will notice that in the picture above, the amino acid glycine has a “H” in the shaded region whereas the amino acid isoleucine has a four carbon attachment. This shaded region is often referred to as the “R” group and again, it is what makes one amino acid different from another amino acid. The “R group” in chemistry is a term used to describe the side chain that is attached to a “core” part of a molecule. The “core part” is generally the same but the “R group” varies from molecule to molecule.

There are twenty amino acids found in living organisms. They all have different "R" groups but the other two parts remain the same. You do not need to memorize what *each* of the twenty amino acids looks like, BUT, you should be able to recognize the difference between a lipid, a carbohydrate, and an amino acid.

The next thing is to hook these amino acids together. This is a very common chemical reaction in biology called **"dehydration synthesis" (Figure 2.8a).** It basically means what it sounds like: we are going to "lose" or dehydrate out the water between two amino acids:

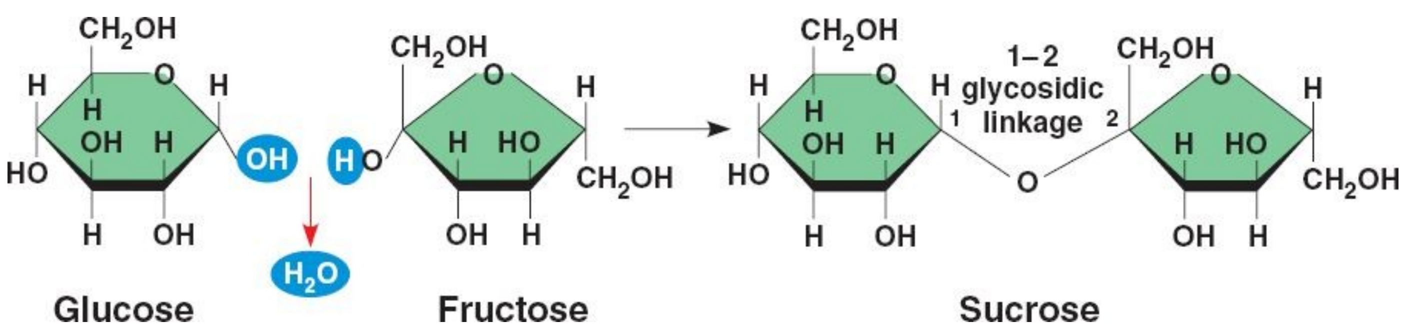
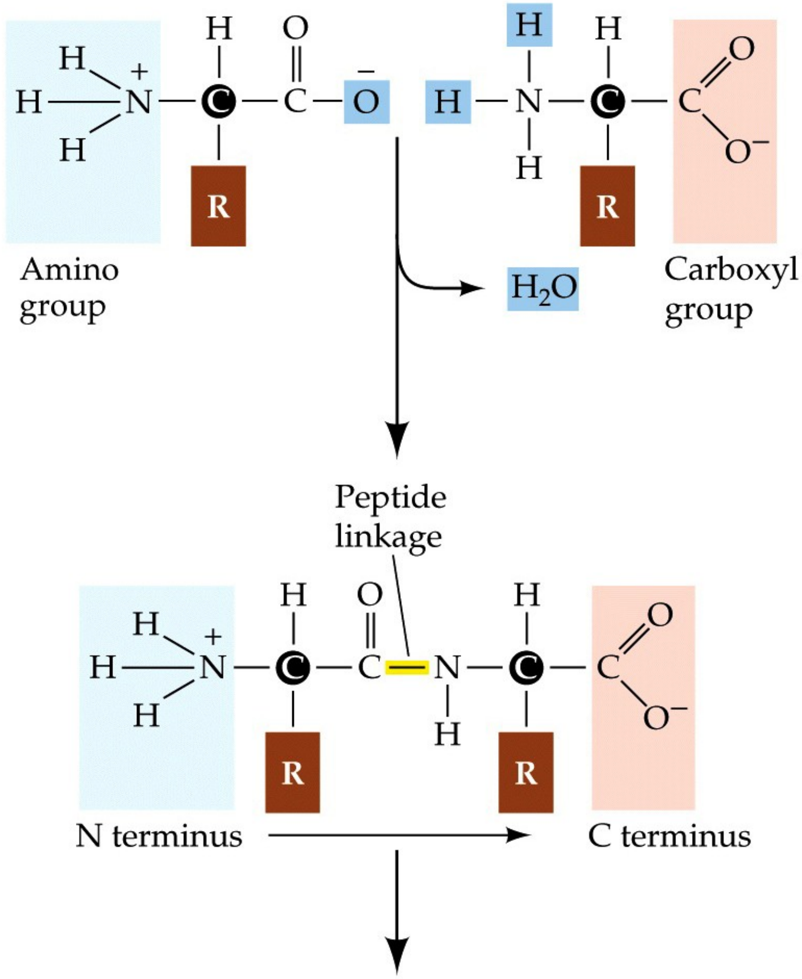


Figure 2.8a

This does not usually happen on its own in living systems. Right now, just pretend it's magic. Later we will learn how this happens. Since we are here, the opposite reaction, hydrolysis, can also occur. In Hydrolysis, we basically split a bigger molecule into smaller molecules by adding water between them.

After dehydration synthesis is done, you are left with two amino acids hooked together by a covalent bond. We have a special name for this covalent bond which is only used when it's between two amino acids. We call it a **peptide bond.**

A peptide bond connects two adjacent amino acids (Figure 2.9a). Dehydration synthesis is not only used to hook amino acids together. It is a very common reaction that we will see over and over again in the building of many macromolecules. I just introduce it here because it is one of the first times we see the reaction taking place. Actually, the hooking of the fatty acids to the glycerol (back at the lipids section) is another place where dehydration synthesis takes place.



H
O
H
H
+
H—N—C—C—O
H—N—C—C
O
H
H
O⁻
R
R
Amino group
H2O
Carboxyl group
Peptide linkage
H
O
H
H
+
H—N—C—C—N—C—C
O
H
H
O⁻
R
R
N terminus
C terminus

Figure 2.9a

Now, if you hook a whole bunch of amino acids together in a big long chain, the chain will fold up and eventually form a **polypeptide chain (Figure 2.10a).**

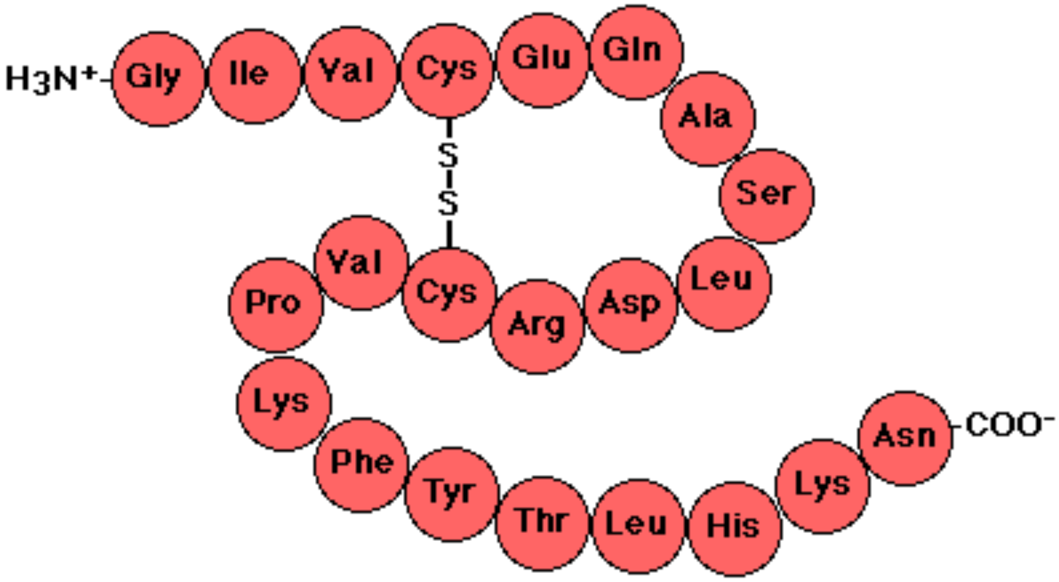


Figure 2.10a

Just as you can see in this picture, some amino acids are attracted to other amino acids. This is because they form hydrogen bonds. That is because some amino acids are slightly negative in charge and some are slightly positive in charge.

As the polypeptide chain begins to fold up, it eventually forms the three dimensional protein.

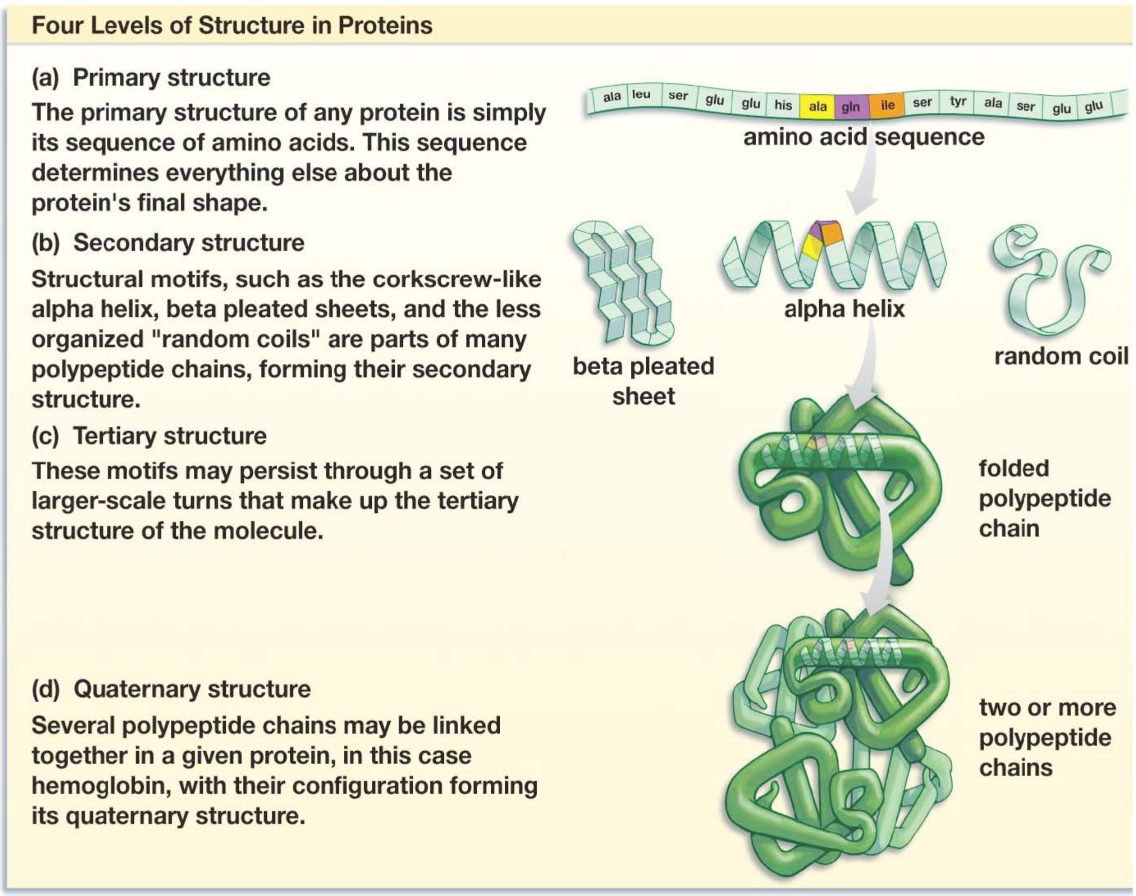
Proteins have four levels of structure.

1) The first level is called the **primary structure** and simple comprised of the sequence in which the amino acids occur. The other structures levels results due to the bonding (usually hydrogen bonds) of certain amino acids to one another.

2) In the **secondary structure**, certain repeating patterns (such as alpha helices and beta pleated sheets) form as common sequences of amino that result in repeating patterns.

3) The **tertiary structure** results from the repeating secondary patterns.

4) Finally, several different chains (along with each containing it's own primary, secondary and tertiary structures come together to form a full functioning protein. The picture below shows the



four levels of protein structure (Figure 2.11a).

Now this is extremely important!: The shape of the protein after it is all finished is very, very, VERY important. Even the slightest little change in the shape of the protein can mean absolute death to a living thing (including a person). So, the order in which those amino acids are in is also very important (because it will determine the shape). You need to remember that because it will be so important for almost everything else we do. Later on, if you are really good, I'll tell you how every genetic disease you can imagine is caused by a protein that doesn't have the right shape!

Proteins can also lose their important three dimensional shape. Although covalent bonds are very strong, the hydrogen bonds that hold the secondary and tertiary structures of proteins tend to be fairly weak. High temperatures can disrupt the hydrogen bonds and cause the protein to unravel or denature. When this happens, the protein loses its specific 3D structure and therefore most (if not all) of its functional properties. This essentially what happens on a large scale when you put an egg in boiling water. A normal, uncooked egg has a very liquid like state. But a hard-boiled egg is like Jello. That is because the individual proteins have denatured and have stuck to one another to form a solid mass of protein.

The last group of macromolecules are Nucleic acids. Nucleic acids are made up of monomers called Nucleotides. Nucleotides consist of three parts: 1) A Nitrogenous base 2) A Phosphate group and 3) a sugar. Molecules such as DNA are nucleic acids and are made up of nucleotides. Here is a generalized view of a nucleotide (Figure 2.12a).

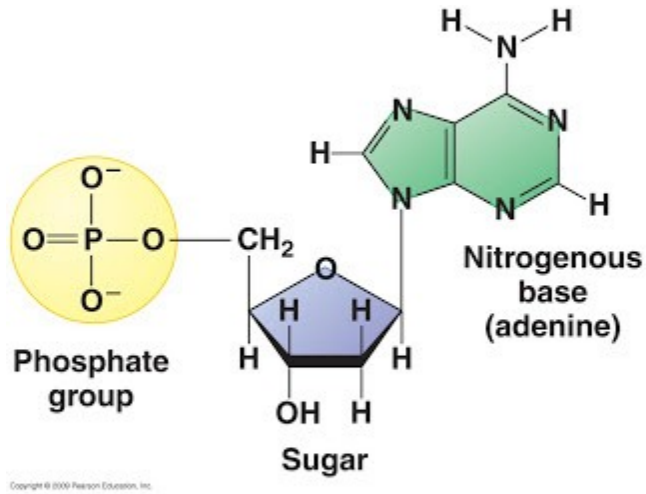


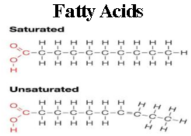
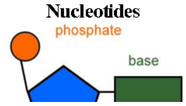
Figure 2.12a

We will discuss nucleic acids in much more detail in Lecture 8.

Here is a summary chart of the four basic types of macromolecules (Table 3.5)

Table 3.5

Macromolecules

Biological Macromolecule	Function	Monomer (building block)	Examples
Carbohydrate Chemical test: *Benedict's for simple sugar* *Lugol's iodine for complex sugar*	▪ short term energy storage ▪ Structural support in plants	**Monosaccharides** 1:2:1 ratio of C:H:O	▪ Glucose is $C_6H_{12}O_6$ Polysaccharides: ▪ starch (plants) ▪ glycogen(animals) ▪ cellulose (cell wall)
Lipids Chemical test: *Brown paper stain* DOES NOT DISSOLVE/MIX WITH WATER	• long term energy storage • chemical messengers • Insulation • Protects soft organs	**Fatty Acids**  	• Fat • Oil • Wax • hormones
Proteins Chemical test: *Biuret's*	• catalyze chemical reactions • Structural components(traits) • Transport molecules • Contractile proteins in muscles • Body defense • Signaling • Storage	**Amino Acids** - contain C, H, O, and N There are 20 different amino acids found in proteins, each with a different side chain.	• Enzymes • Hemoglobin – transports O_2 in blood • Insulin – regulates blood sugar
Nucleic Acids	• Carries genetic information	**Nucleotides**  	• DNA • RNA

Coming Up….(but you need to know at least this part for this coming quiz!)…

All living things are made up of cells. There are basically two types of cells that exist, **prokaryotic cells** and **eukaryotic cells.** Organisms such as bacteria for example, are made up of prokaryotic cells. Prokaryotic cells are usually very small and are less complex than eukaryotic cells. Prokaryotic cells have a cell membrane and have DNA floating around loose inside the cytoplasm.

Eukaryotic cells are generally larger and have their DNA enclosed in a specialized membrane called the nucleus.

Cells are made up of parts called organelles. We will learn more of these later and in more detail. For now, make sure you know these organelles, which types of cells have them, and what their basic functions are.

Name of Organelle:	**Cells that have them:**	**Basic Function:**
Nucleus	Eukaryotic Cells	The brain of the cell
Cell Membrane	Both	Regulates what moves in/out of a cell.
Cell Wall	Eukaryotic Plant Cells and Prokaryotic Cells	Protects the inside of the cell
Mitochondria	Eukaryotic Cells	Powerhouse of the cell; generates ATP
Chloroplasts	Eukaryotic Plant Cells (and a couple of other types of eukaryotic cells)	Energy exchange banks; converts light energy into sugar
Ribosomes	Both	Makes proteins

PLC #2

1) Get some (maybe 50-75) 3 x 5 or 4 x 6 note cards. Take all of the information in the above lecture notes, assignment (below), and any film or reading assignments and put the information on the note cards. Each card should only have one or two items on it. For example, you might have the word "covalent bond" on one side and a description or picture of the covalent bond on the other side. That will be ONE card. When you are done making your cards, you should have ALL of the information you need to know on the collection of cards. Also, be sure that you understand what you are writing down on your cards. Do not just memorize everything word for word; make sure you write your cards in your own words!

2) Next, get some blank sheets of paper. Go through all of your note cards one by one and see if you can write (without looking) the information on the opposite side of the card (write...not TYPE). GO THROUGH ALL of the cards 4 times (always trying to write what is on the other side). Now, get another sheet of paper and do this again BUT THIS TIME, separate the cards you get right from those that you get wrong. You will turn in this 5th attempt!

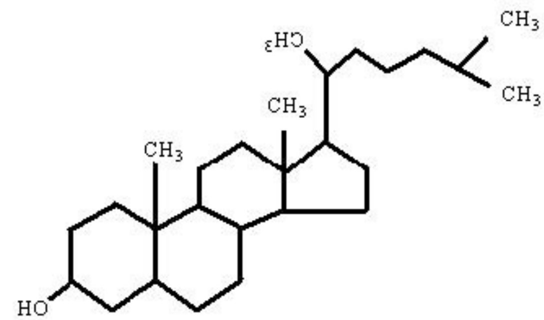
3) Finally, go through the cards YOU GOT WRONG ONLY 5 more times! Once again, have a sheet of paper out and try to write down what is on the opposite side (write...not type!)

4) To complete this assignment, take a picture of your notecards and post (a single picture) along with two or three sentences explaining your results.

1) Which of the following is a polysaccharide?

A) Cellulose
B) Glucose
C) Amylase
D) Glycine
E) Sucrose

2) The molecule to the right is an example of a:



A) Protein
B) Carbohydrate
C) Starch
D) Lipid
E) Monosaccharides

3) From the article "Rebuilding The Food Pyramid", which of the following is present in the new food pyramid, but did not exist in the old food pyramid?

A) daily exercise B) eating fruit C) eating vegetables D) eating meat E) using oils

4) From the article, rebuilding the food pyramid, which food will cause a greater rise in blood sugar levels, a candy bar or a potato? Why?

5) What happens when a protein becomes **denatured**?

6) What is the difference between LDL's and HDL's?

7) What are the three parts of a nucleotide? What are nucleic acids used for?

8) What are glycoproteins and what do they do?

9) What causes acid rain (what chemicals and where do they come from)? What kind of damage does it do? (Book or Internet)

Words that you may be asked to define or use in fill-in-the blank types of questions:

Carbohydrate, Monosaccharide, Disaccharide, Polysaccharide, Protein, Primary, Secondardy, Tertiary and Quartenary Protein Structure, Enzymes, Structural Proteins, Amino Acid, Lipid, Cholesterol, Glycerol, Fatty Acid, Saturated Fat, Unsaturated Fat, LDL, HDL, Hydroxyl, Carboxyl, Amino, Sulfhydryl, Phosphate, Protein Denaturing, Prokaryotic Cell, Eukaryotic Cell, Ribosome, Mitochondria, Cell Membrane, Nucleus, Cell Wall, Chloroplast, Epidemiologist, Monomer, Polymer, Dehydration Synthesis, Hydrolysis

Also, if you did not completely finish assignment #1, you should go back and do it. You don't get the credit….but you need to get it in order to do well on the big upcoming midterm. Also, I suggest you take the information from week 1 and make notecards and go through the whole process as you did before